June 1995

Physics 30

Grade 12 Diploma Examination

Alberta
EDUCATION

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Physics 30

Grade 12 Diploma Examination

Description

Time: 2.5 h. You may take an additional 0.5 h to complete the examination.

Total possible marks: 70

This is a **closed-book** examination consisting of

- 37 multiple-choice and 12 numerical-response questions each with a value of one mark
- 2 written-response questions with a combined value of 21 marks

This examination contains sets of related questions. A set of questions may contain multiple-choice and/or numerical-response and/or written-response questions.

Tear-out data sheets are included near the back of this booklet.

The blank perforated pages at the back of this booklet may be torn out and used for your rough work. No marks will be given for work done on the tear-out pages.

Instructions

- Fill in the information required on the answer sheet and the examination booklet as directed by the presiding examiner.
- You are expected to provide your own scientific calculator.
- Use only an HB pencil for the machine-scored answer sheet.
- If you wish to change an answer, erase **all** traces of your first answer.
- Consider all numbers used in the examination to be the result of a measurement or observation.
- Do not fold the answer sheet.
- The presiding examiner will collect your answer sheet and examination booklet and send them to Alberta Education.
- Read each question carefully.
- Now turn this page and read the detailed instructions for answering machine-scored and written-response questions.

Multiple Choice

- Decide which of the choices **best** completes the statement or answers the question.
- Locate that question number on the separate answer sheet provided and fill in the circle that corresponds to your choice.

Example

This examination is for the subject of

A. biology
B. physics
C. chemistry
D. science

Answer Sheet

Ⓐ ● Ⓒ Ⓓ

Numerical Response

- Record your answer on the answer sheet provided by writing it in the boxes and then filling in the corresponding circles.
- If an answer is a value between 0 and 1 (e.g., 0.25), then be sure to record the 0 before the decimal place.
- **Enter the first digit of your answer in the left-hand box and leave any unused boxes blank.**

Examples

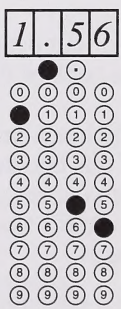
Calculation Question and Solution

If a 121 N force is applied to a 77.7 kg mass at rest on a frictionless surface, the acceleration of the mass would be _____ m/s^2.
(Round and record your answer to three digits on the answer sheet.)

$$a = \frac{F}{m}$$

$$a = \frac{121\ \text{N}}{77.7\ \text{kg}} = 1.5572716$$

Record 1.56 on the answer sheet →

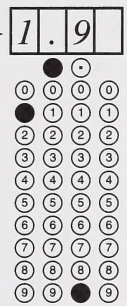


Calculation Question and Solution

A microwave of wavelength 16 cm has a frequency, expressed in scientific notation, of $b \times 10^9$ Hz.
The value of ***b*** is _____.
(Round and record your answer to two digits on the answer sheet.)

$f = c/\lambda$
$= (3.00 \times 10^8 \text{ m/s})/(0.16 \text{ m})$
$f = 1.875 \times 10^9$ Hz

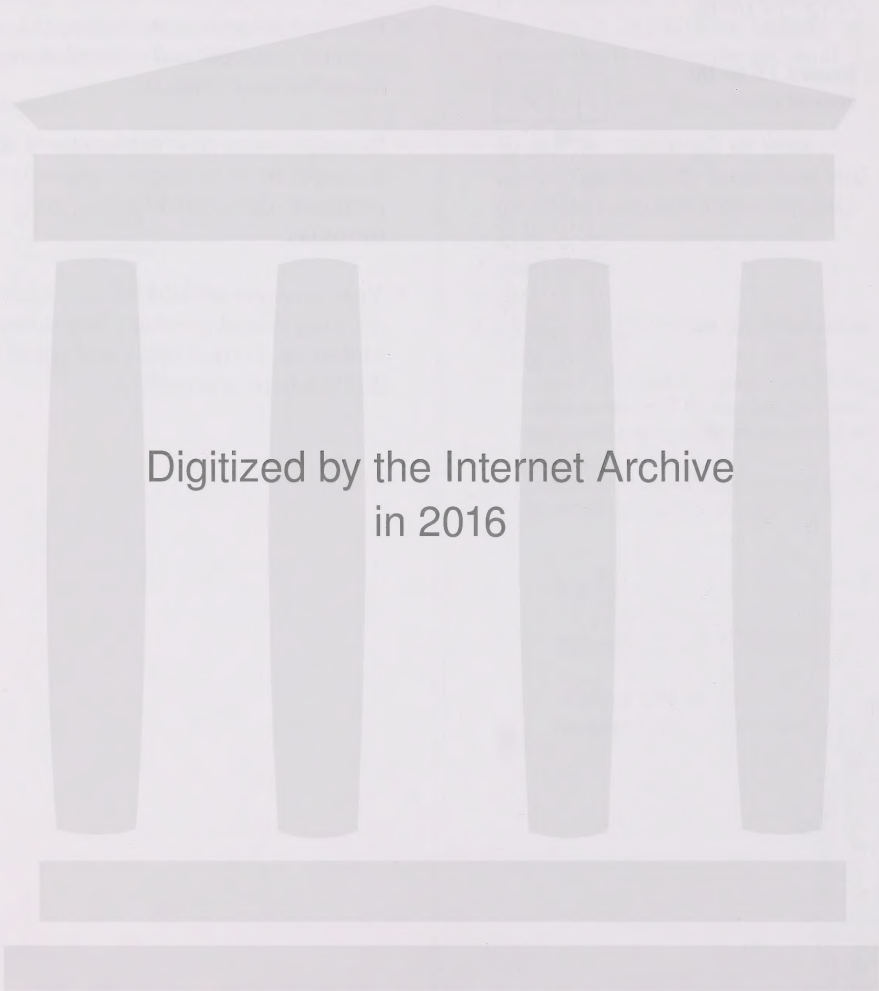
Record 1.9 on the answer sheet →



Written Response

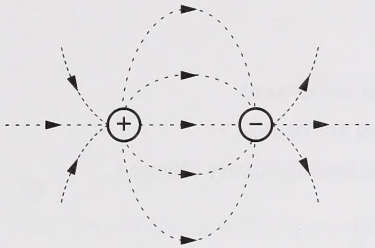
- Write your answers in the examination booklet as neatly as possible.
- For full marks, your answers must be well organized and address **all** the main points of the question.
- Relevant scientific, technological, and/or societal concepts and examples must be identified and explicit.
- Descriptions and/or explanations of concepts must be correct and reflect pertinent ideas, calculations, and formulas.
- Your answers **should be** presented in a well-organized manner using complete sentences, correct units, and significant digits where appropriate.

Do not turn the page to start the examination until told to do so by the presiding examiner.

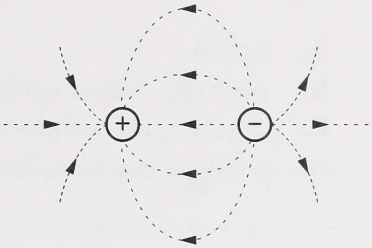


1. One object has a positive charge, while a second object has a negative charge. The diagram that **best** represents the electric field surrounding the charges is

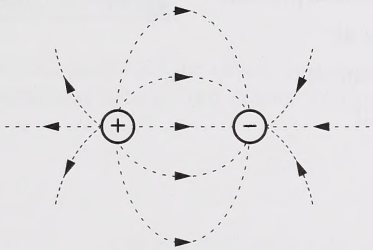
A.



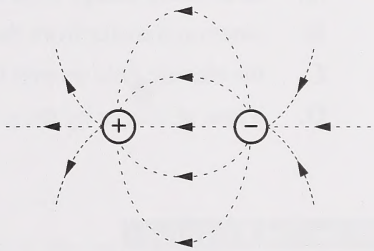
B.



C.



D.



2. Two positive charges, q_1 of 2.0×10^{-6} C and q_2 of 3.0×10^{-6} C, are separated by 3.0 m. The electric force between them is

A. 2.0×10^{-3} N (repulsion)

B. 2.0×10^{-3} N (attraction)

C. 6.0×10^{-3} N (repulsion)

D. 6.0×10^{-3} N (attraction)

3. Many asthma cases are due in part to airborne dung pellets from dust mites. A scientist in Britain invented a fabric for use in air filters and carpets that removes the airborne pellets by electrostatic attraction. If the dung pellets are neutral or have a positive or negative charge, the fabric in the air filter would have to contain some fibres that are

A. neutral
B. positively charged and some fibres that are neutral
C. negatively charged and some fibres that are neutral
D. positively charged and some fibres that are negatively charged

4. A neutral pithball is attracted to a positively charged pithball because of

A. an induced charge separation on the neutral pithball
B. electron transfer from the surrounding air
C. the electric field around the positive pithball
D. a loss of charge by the positive pithball

Numerical Response

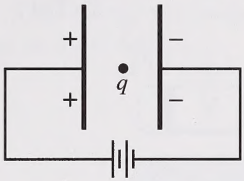
1. At a distance 5.06 m from a point charge of magnitude 6.02×10^{-6} C, the magnitude of the electric field strength is $b \times 10^{3}$ N/C. The value of b is _____ . (Round and record your answer to three digits.)

5. What is the distance between a stationary point charge of 1.20×10^{-9} C and an alpha particle if the alpha particle initially accelerates at 7.35×10^{8} m/s^2?

A. 0.353 m
B. 0.594 m
C. 0.706 m
D. 0.840 m

Use the following information to answer the next question.

A Point Charge between Parallel Plates



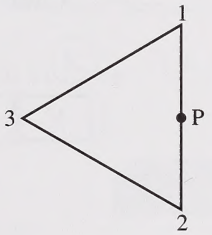
Two vertical plates 2.50 cm apart have an unknown voltage across them. A point charge of $q = 3.00 \times 10^{-6}$ C is placed between the plates and experiences an electrostatic force of 4.00×10^{-4} N.

Numerical Response

2. The voltage across the plates is _____ V.
(Round and record your answer to three digits.)

Use the following information to answer the next question.

Resultant Electric Field

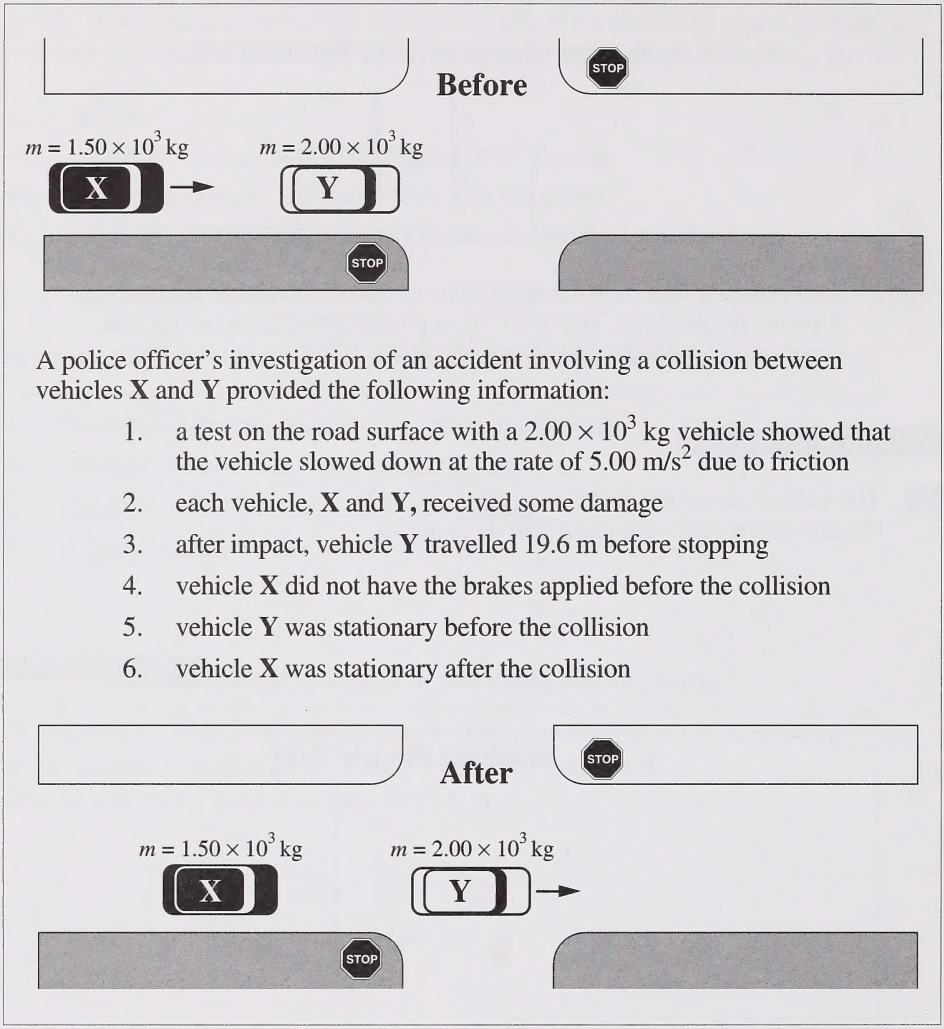


Three equal positive charges are located at the vertices of an equilateral triangle.

6. The direction of the electric field at point P is

A. into the page
B. out of the page
C. to the left of the page
D. to the right of the page

Use the following information to answer the next three questions.



A police officer's investigation of an accident involving a collision between vehicles **X** and **Y** provided the following information:

1. a test on the road surface with a 2.00×10^3 kg vehicle showed that the vehicle slowed down at the rate of 5.00 m/s^2 due to friction
2. each vehicle, **X** and **Y,** received some damage
3. after impact, vehicle **Y** travelled 19.6 m before stopping
4. vehicle **X** did not have the brakes applied before the collision
5. vehicle **Y** was stationary before the collision
6. vehicle **X** was stationary after the collision

7. What was the speed of vehicle **Y** just after the collision?

A. 19.6 m/s
B. 14.0 m/s
C. 11.0 m/s
D. 1.56 m/s

Numerical Response

*Use your answer from **Multiple Choice 7** to answer **Numerical Response 3.***

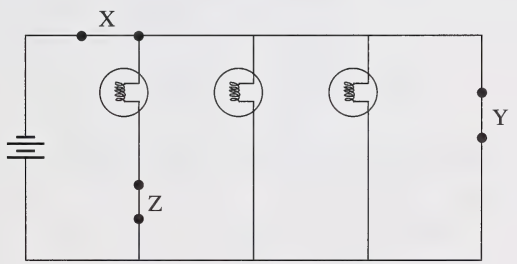
3. Immediately before the collision, the speed of vehicle **X** was _____ m/s. (Round and record your answer to three digits.)

8. In analyzing the scene of the accident, the officer most often applied her understanding of

A. Newton's First Law
B. Newton's Second Law
C. the Law of Conservation of Energy
D. the Law of Conservation of Momentum

Use the following information to answer the next question.

Light Circuits



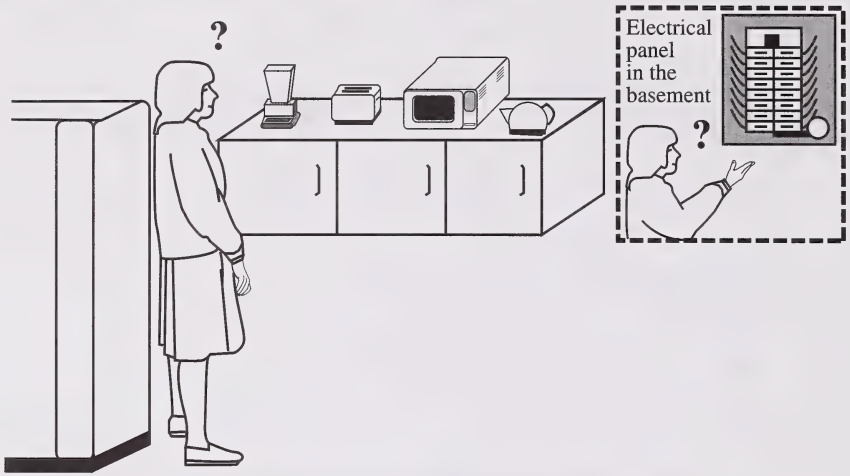
9. In order to light all three bulbs in the circuit, the switches at *X, Y,* and *Z,* respectively, must be

A. closed, closed, and open
B. closed, closed, and closed
C. closed, open, and closed
D. open, closed, and closed

Use the following information to answer the next three questions.

Kitchen Frustration

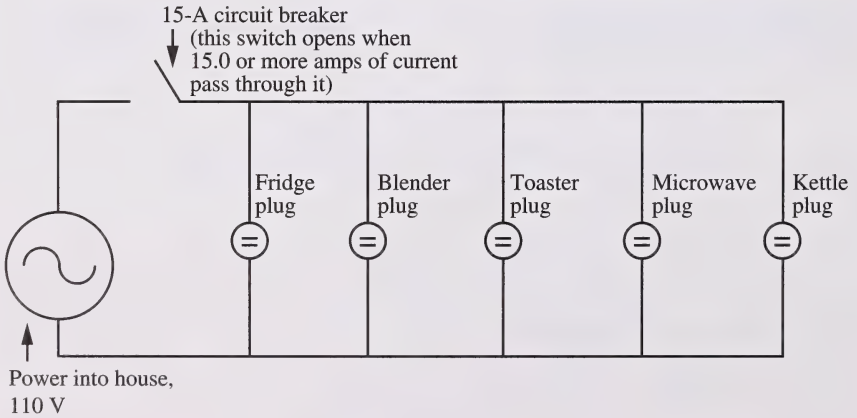
The McLary family is having a recurring problem in their kitchen. Every time a meal is prepared, the power shuts off. They have found that a circuit breaker in the basement keeps on "tripping" or shutting off.



The McLarys read the manufacturers' labels on all the appliances and record the power rating as follows:

Fridge:	200 W
Blender:	60 W
Toaster:	180 W
Microwave:	720 W
Kettle:	1500 W

The diagram below represents the circuit of the McLary's kitchen.



10. The reason the circuit breaker keeps tripping is that

A. there is too much resistance in the circuit
B. there is too much current being used
C. the combined currents of all the appliances is too low
D. the combined voltages of all the appliances is too high

11. The McLary's microwave oven takes 110 s to boil a cup of water, whereas their kettle takes 63 s to boil an equal volume of water.

Based on this information, the

A. microwave oven does more work than the kettle
B. microwave oven uses less energy than the kettle
C. kettle uses less power than the microwave oven
D. kettle is more efficient

Numerical Response

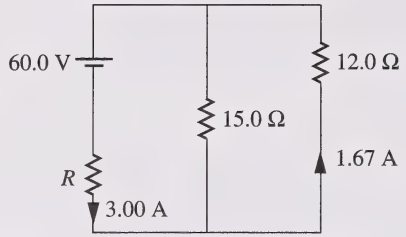
4. If the McLary's microwave oven is used for a total of 3.00 h and the average cost of electrical energy is 7.00 ¢/kWh, then the cost of using the microwave will be _____ ¢.
(Round and record your answer to three digits.)

Numerical Response

5. A 28.0 V battery produces a 7.00 A current through a 4.00 Ω resistance. The power output, expressed in scientific notation, is $b \times 10^{w}$ W.
The value of b is _____ .
(Round and record your answer to three digits.)

Use the following information to answer the next question.

Electrical Circuit



In this circuit, the voltages and currents are as indicated.

Numerical Response

6. The current through the 15.0 Ω resistor is _____ A.
(Round and record your answer to three digits.)

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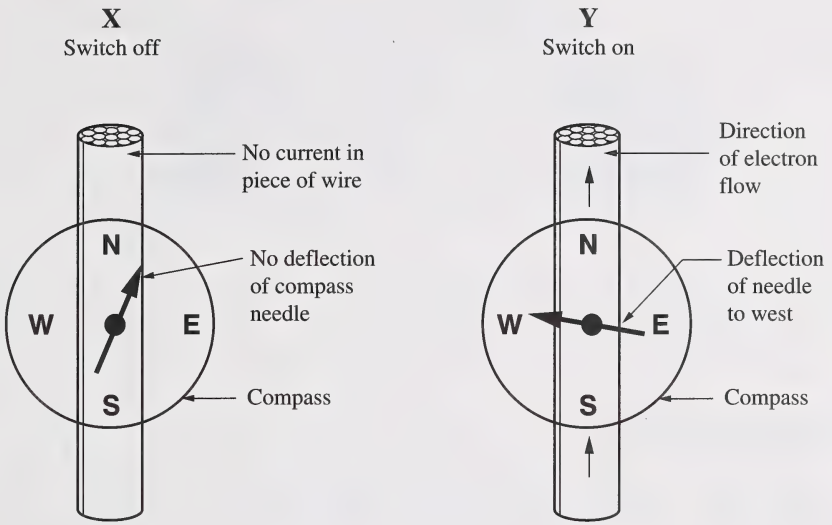
12. In a transformer for a doorbell, 115 V AC is to be stepped down to 24.0 V AC. If the primary coil has 600 turns, how many turns should be on the secondary coil?

A. 125
B. 215
C. 485
D. 2875

Use the following information to answer the next question.

Current Flow in a Wire



13. If the direction of the electron flow in diagram **Y** is reversed, the compass needle will point

A. north
B. south
C. east
D. west

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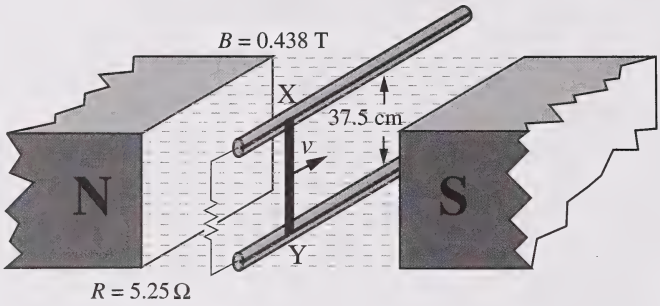
14. Compasses are not used to navigate in the Far North because the

A. magnetic field does not extend to the Far North
B. magnetic field is non-uniform near the Far North
C. magnetic field lines point down to the Earth in the Far North
D. magnetic field lines are parallel to the Earth's surface in the Far North

Use the following information to answer the next two questions.



Wire XY is pulled along the rails in order to produce an electric circuit. It is pulled at a constant speed v through a magnetic field of strength B. As a result, a voltage V of 5.41 V is induced.

Numerical Response

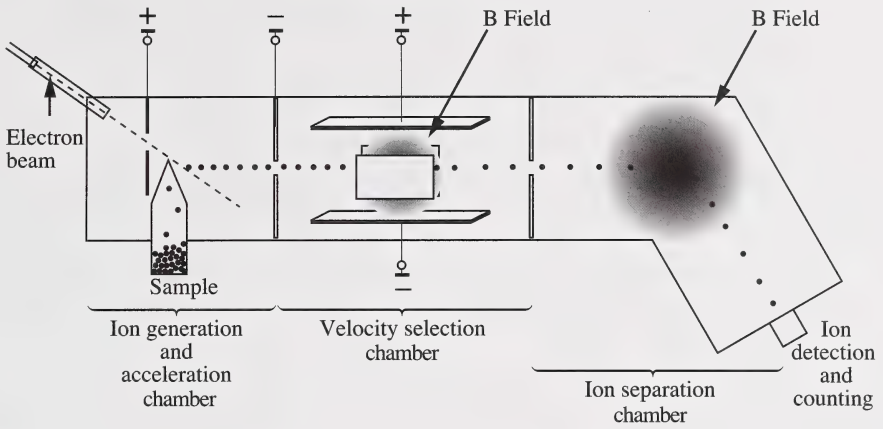
7. The speed at which the wire is being pulled is _____ m/s.
(Round and record your answer to three digits.)

Numerical Response

8. The applied force on the wire required to induce a constant voltage of 5.41 V, expressed in scientific notation, is $\boldsymbol{b} \times 10^{-w}$ N. The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

Use the following information to answer the next question.

Mass Spectrometer



A biochemist uses a mass spectrometer to identify pollutants in a water sample. The ions from the sample are accelerated and enter the velocity selection chamber. Only particles with a certain velocity will pass through the electric and magnetic fields.

15. Which derived equation could be used to determine the speed of the ions as they enter the ion separation chamber?

A. $v = \dfrac{|\vec{E}|}{B_{\perp}}$

B. $v = \sqrt{\dfrac{2E_{k}}{m}}$

C. $v = \dfrac{qB_{\perp}R}{m}$

D. $v = \dfrac{mg}{qB_{\perp}}$

16. An alpha particle and an electron travelling at the same speed enter perpendicularly into a uniform magnetic field. Which of the following statements concerning the acceleration of the particles is correct?

A. The acceleration of the alpha particle is greater because it experiences the greater force.

B. The acceleration of the electron is greater because it experiences the greater force.

C. The acceleration of the alpha particle is greater because its mass is greater.

D. The acceleration of the electron is greater because its mass is smaller.

17. An electron with velocity v moves in a magnetic field of strength B and experiences a force F. An alpha particle with velocity $v/2$ moves through a magnetic field of strength $5B$ and experiences a force of

A. $2F/5$

B. $5F/2$

C. $5F$

D. $10F$

18. An alpha particle travels in an orbit with a radius of 5.00 cm in a magnetic field of strength 0.80 T. What is the time taken to complete one orbit?

A. 2.60×10^{-8} s

B. 8.00×10^{-8} s

C. 1.02×10^{-7} s

D. 1.63×10^{-7} s

19. A unit combination equivalent to the tesla is

A. $\frac{\text{kg}}{\text{A}\cdot\text{s}^2}$

B. $\frac{\text{N}\cdot\text{A}}{\text{m}}$

C. $\frac{\text{kg}\cdot\text{m}}{\text{A}\cdot\text{s}^2}$

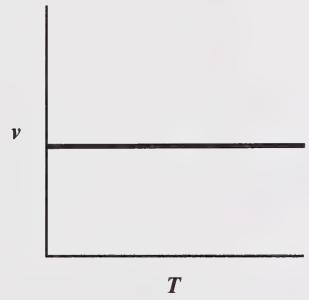
D. A/kg

20. A stream of neutral atoms in a vacuum produces

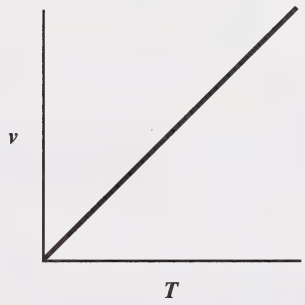
A. electromagnetic waves
B. a magnetic field only
C. an electric field only
D. no magnetic or electric fields

21. Which graph **best** represents the relationship between the speed v of an electromagnetic wave in vacuum and its period T?

A.



B.



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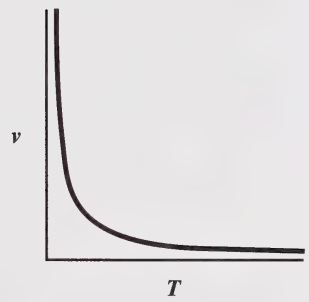

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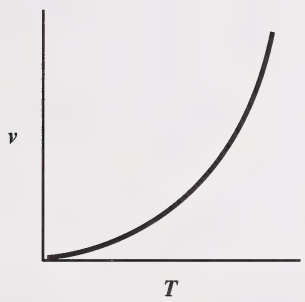


Use the following information to answer the next four questions.

> Astronomers believe that one of the best locations for finding planets is in areas of space where new stars are being formed. Because planets do not emit light, they have to be detected by the behaviour of the star.

22. Initially, young stars are invisible because they exist at a low temperature. In what portion of the electromagnetic spectrum might astronomers initially attempt to detect a young star?

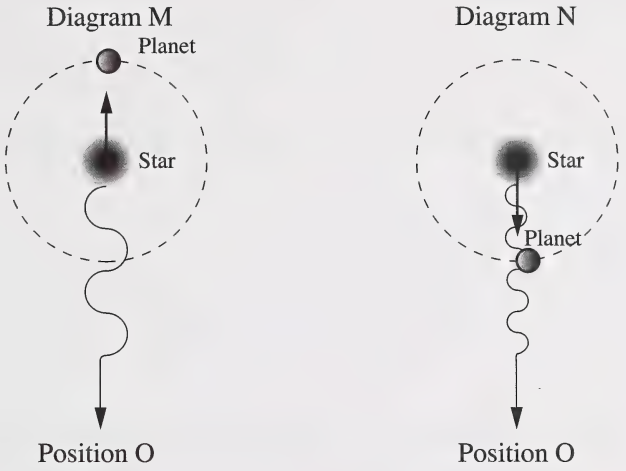
A. Infrared
B. Ultraviolet
C. X-ray
D. Gamma ray

23. A technique used to detect the presence of planets moving around a star is to find out whether a star has a wobble in its movement. A planet may exist, because the wobble is caused by the interaction of the star's and the planet's

A. electric fields
B. magnetic fields
C. gravitational fields
D. cosmic fields

Use this additional information to answer the next two questions.

As a planet moves around a star, the gravitational force of attraction pulls the star away from Position O, as shown in Diagram M. In Diagram N, the star pulls toward Position O.



24. If an astronomer at Position O was watching the emitted light in the visible portion of the electromagnetic spectrum, the shifts observed in Diagrams M and N, respectively, would be

A. a shift of wavelengths to the red end of the spectrum and a shift of wavelengths to the blue end of the spectrum

B. a shift of wavelengths to the blue end of the spectrum and a shift of wavelengths to the red end of the spectrum

C. a shift of wavelengths to the red end of the spectrum and a shift of wavelengths to the red end of the spectrum

D. a shift of wavelengths to the blue end of the spectrum and a shift of wavelengths to the blue end of the spectrum

25. An astronomer finds that the average time it takes for the shift in wavelength from Diagram M to Diagram N is 28 days. From this, the astronomer may conclude that the period for the planet is

A. 28 days

B. 56 days

C. 84 days

D. 112 days

26. If the period of an electromagnetic wave is 1.96×10^{-15} s, its wavelength in air is

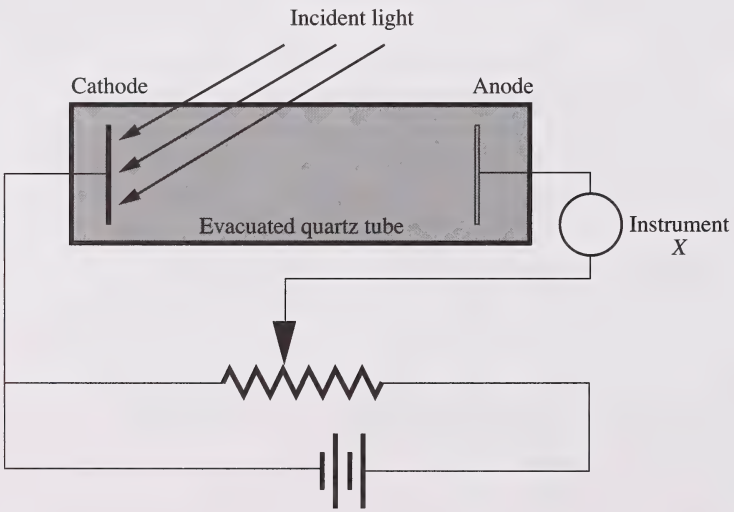
A. 1.53×10^{23} m
B. 5.08×10^{14} m
C. 1.70×10^{-6} m
D. 5.88×10^{-7} m

27. The period of an electromagnetic wave is doubled. The wavelength is then

A. unchanged
B. quartered
C. halved
D. doubled

Use the following information to answer the next three questions.

A Physics Apparatus



28. The apparatus in the illustration would most likely be used to demonstrate the

A. Millikan experiment
B. Photoelectric effect
C. Compton effect
D. Doppler effect

29. The reading of instrument *X* would be increased if the incident light's

A. intensity were decreased and its frequency kept constant
B. intensity were increased and its frequency kept constant
C. frequency were increased and its intensity kept constant
D. frequency were decreased and its intensity kept constant

30. Instrument *X* is most likely

A. an ammeter
B. an ohmmeter
C. a magnetometer
D. a voltmeter

Numerical Response

9. A metal has a work function of 1.82 eV. Light with a frequency of 8.31×10^{14} Hz is incident on the metal. The stopping voltage is _____ V.
(Round and record your answer to three digits.)

Numerical Response

10. The minimum potential difference required by an X-ray tube to produce a wavelength of 7.25×10^{-9} m, expressed in scientific notation, is $b \times 10^{w}$ V.
The value of b is _____ .
(Round and record your answer to three digits.)

31. X-rays can be classified as

A. high frequency electromagnetic waves
B. long-wavelength radio waves
C. low-energy cathode rays
D. ionized gas particles

32. Doctors often use X-ray photographs as diagnostic tools. The property that makes it possible to show broken bones is that X-rays

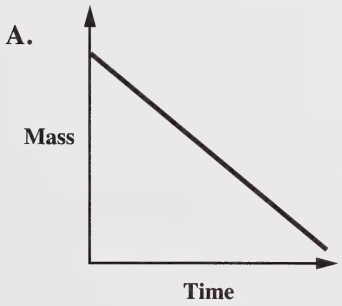
A. consist of high frequency electromagnetic waves
B. penetrate substances to different depths
C. cannot be deflected by electric and magnetic fields
D. are produced when high energy electrons strike a metal target

Numerical Response

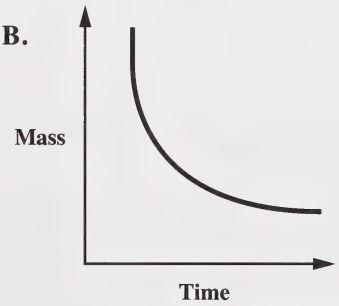
11. In a Geiger-Muller tube (a type of radiation detector), electrons are accelerated from rest by a potential difference of 4.05×10^2 V. The speed of the electrons when they strike the collecting anode, in scientific notation, is $\boldsymbol{b} \times 10^7$ m/s.
The value of $\boldsymbol{b}$ is _____ .
(Round and record your answer to three digits.)

33. Radium is a radioactive element. Which of the following graphs corresponds to the relationship between the mass of radium that is remaining and time?

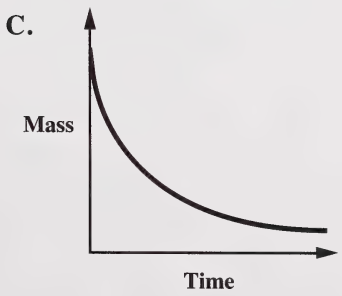
A.



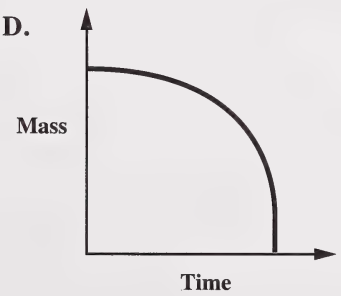
B.



C.



D.



34. Some smoke detectors are activated when the current produced by a radioactive source fluctuates. If the activity rate of a radium source is 3.7×10^4 disintegrations/second and each disintegration results in the release of one alpha particle, the effective current produced by the radioactive source is

A. 2.4×10^{-13} A

B. 1.2×10^{-14} A

C. 6.0×10^{-15} A

D. 5.0×10^{-16} A

35. An unstable atomic nucleus releases a photon having an energy of 6.60×10^{-11} J. The type of radiation identified with this magnitude of energy is

A. radio waves

B. gamma rays

C. ultraviolet rays

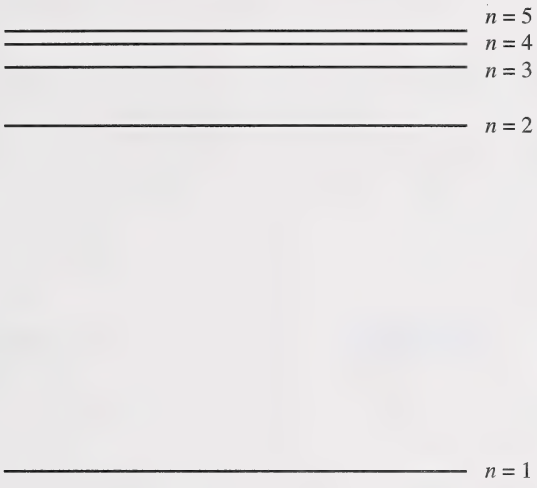
D. visible light waves

Numerical Response

12. For an unknown radioactive element "X," 48.0 g of a 768 g sample remain active after 10.2 h. The half-life is _____ h.
(Round and record your answer to three digits.)

Use the following information to answer the next two questions.

Energy Level Diagram of a Hydrogen Atom



36. Which of the following is a true statement about the spectrum produced when hydrogen electrons fall from level $n = 5$?

A. The lowest frequency results from the transition $n = 5$ to $n = 1$.

B. The longest wavelength produced is in the visible region.

C. The shortest wavelength produced is in the ultraviolet region.

D. The shortest wavelength is produced by the transition $n = 5$ to $n = 4$.

37. When a hydrogen electron falls from $n = 4$ to $n = 2$, there will be an emission of a photon of light with wavelength

A. 4.8×10^{-7} m

B. 3.6×10^{-7} m

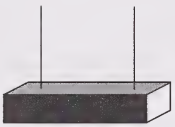
C. 2.9×10^{-7} m

D. 1.2×10^{-7} m

Written Response – 11 marks

Use the following information to answer written-response question 1.

A chronograph is a sophisticated device commonly used by technicians to find the speed of a bullet fired from a gun. Before this technology was developed, the speed of a bullet was determined using different methods. A simplification of one method of determining the speed of a bullet requires shooting the bullet into the end of a stationary wooden block suspended by two long strings. This method is illustrated below.



$\vec{v}_i = 0$ m/s

$\vec{V}_i = ?$

In this case, a bullet (m = 10.89 g) is shot from a handgun and becomes embedded in a 2.20 kg block of wood. The block of wood swings upward a vertical distance of 69.1 cm.

1. Using the information provided, the Law of Conservation of Energy, and the Law of Conservation of Momentum, **describe in detail** (written account) the method used and **show how** to calculate the speed of the bullet just before its impact with the block.

In your solution, identify where you applied the Law of Conservation of Energy and the Law of Conservation of Momentum.

Note: A maximum of 8 marks will be awarded for the physics used to solve this problem. A maximum of 3 marks will be awarded for the effective communication of your response.

(Written-response Question 2 begins on the next page.)

Written Response – 10 marks

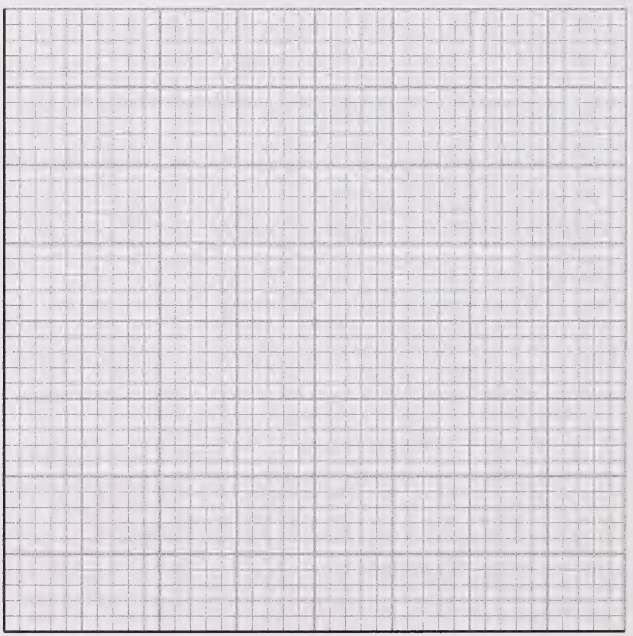
Use the following information to answer written-response question 2.

While studying a radioactive phosphorus $^{34}_{15}P$, it was discovered that a 128 g sample had decayed to 4.48 g after 60 s. The following table provides data corresponding to the decay.

Mass (g)	128.0	73.0	41.9	23.9	13.7	7.80	4.48
Time (s)	0	10	20	30	40	50	60

2. **a.** On the grid below, graph the data with the manipulated variable on the horizontal axis. Provide a suitable title for your graph.

_____ (Title)



b. Using your graph, or some other appropriate method, determine the half-life of this substance. Indicate how you determined your answer.

c. When material decays, it emits a particle. An experiment similar to the J. J. Thomson experiment is performed to determine the charge-to-mass ratio of this particle. It is found that the particle moves undeflected through mutually perpendicular magnetic and electric fields of 2.00×10^{-3} T and 1.08×10^{4} N/C, respectively. When the electric field is turned off, the particle is found to deflect to a radius of 1.53×10^{-2} m. Using the formula on the data sheets, determine the type of particle emitted. Show all the steps needed to make this determination.

(parts d *and* e *are on the next page)*

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d. Using the section of the periodic table provided below, write the decay equation for the decay in part *c*, identifying the product isotope. (If you were not able to answer part *c*, assume an alpha decay.)

5 B 2.0 Boron 10.81	6 C 2.5 Carbon 12.01	7 N 3.0 Nitrogen 14.01	8 O 3.5 Oxygen 16.00	9 F 4.0 Fluorine 19.00	10 Ne — Neon 20.17
13 Al 1.5 Aluminum 26.98	14 Si 1.8 Silicon 28.09	15 P 2.1 Phosphorus 30.97	16 S 2.5 Sulphur 32.06	17 Cl 3.0 Chlorine 35.45	18 Ar — Argon 39.95
31 Ga 1.6 Gallium 69.74	32 Ge 1.8 Germanium 72.59	33 As 2.0 Arsenic 74.92	34 Se 2.4 Selenium 78.96	35 Br 2.8 Bromine 79.90	36 Kr — Krypton 83.80

e. How would a gamma ray have been affected by passage through a magnetic field as mentioned in part *c*?

You have now completed the examination.
If you have time, you may wish to check your answers.

PHYSICS DATA SHEETS

CONSTANTS

Gravity, Electricity, and Magnetism

Acceleration Due to Gravity **or** Gravitational Field Near Earth	a_g or $g = 9.81\ \text{m/s}^2$ or $9.81\ \text{N/kg}$
Gravitational Constant	$G = 6.67 \times 10^{-11}\ \text{N•m}^2/\text{kg}^2$
Mass of Earth	$M_e = 5.98 \times 10^{24}\ \text{kg}$
Radius of Earth	$R_e = 6.37 \times 10^{6}\ \text{m}$
Coulomb's Law Constant	$k = 8.99 \times 10^{9}\ \text{N•m}^2/\text{C}^2$
Electron Volt	$1\ \text{eV} = 1.60 \times 10^{-19}\ \text{J}$
Elementary Charge	$e = 1.60 \times 10^{-19}\ \text{C}$
Index of Refraction of Air	$n = 1.00$
Speed of Light in Vacuum	$c = 3.00 \times 10^{8}\ \text{m/s}$

Atomic Physics

Energy of an Electron in the 1st Bohr Orbit of Hydrogen	$E_1 = -2.18 \times 10^{-18}\ \text{J}$ or $-13.6\ \text{eV}$
Planck's Constant	$h = 6.63 \times 10^{-34}\ \text{J•s}$
Radius of 1st Bohr Orbit of Hydrogen	$r_1 = 5.29 \times 10^{-11}\ \text{m}$
Rydberg's Constant for Hydrogen	$R_H = 1.10 \times 10^{7}/\text{m}$

Particles

	Rest Mass	Charge
Alpha Particle	$m_\alpha = 6.65 \times 10^{-27}\ \text{kg}$	α^{2+}
Electron	$m_e = 9.11 \times 10^{-31}\ \text{kg}$	e^-
Neutron	$m_n = 1.67 \times 10^{-27}\ \text{kg}$	n^0
Proton	$m_p = 1.67 \times 10^{-27}\ \text{kg}$	p^+

Trigonometry and Vectors

$$\sin\theta = \frac{opposite}{hypotenuse}$$

$$\cos\theta = \frac{adjacent}{hypotenuse}$$

$$\tan\theta = \frac{opposite}{adjacent}$$

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$c^2 = a^2 + b^2 - 2ab\cos C$$

For any Vector $\vec{R}$

$$R = \sqrt{R_x{}^2 + R_y{}^2}$$

$$\tan\theta = \frac{R_y}{R_x}$$

$$R_x = R\cos\theta$$

$$R_y = R\sin\theta$$

Prefixes Used With SI Units

Prefix	Symbol	Exponential Value
pico	p	10^{-12}
nano	n	10^{-9}
micro	μ	10^{-6}
milli	m	10^{-3}
centi	c	10^{-2}
deci	d	10^{-1}

Prefix	Symbol	Exponential Value
tera	T	10^{12}
giga	G	10^{9}
mega	M	10^{6}
kilo	k	10^{3}
hecto	h	10^{2}
deka	da	10^{1}

EQUATIONS

Kinematics

$$\vec{v}_{ave} = \frac{\vec{d}}{t}$$

$$\vec{a} = \frac{\vec{v}_f - \vec{v}_i}{t}$$

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \vec{v}_f t - \frac{1}{2}\vec{a}t^2$$

$$\vec{d} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right)t$$

$$v_f^2 = v_i^2 + 2ad$$

Dynamics

$$\vec{F} = m\vec{a}$$

$$\vec{F}t = m\Delta\vec{v}$$

$$\vec{F}_g = m\vec{g}$$

$$F_f = \mu F_N$$

$$\vec{F}_s = -k\vec{x}$$

$$F_g = \frac{Gm_1m_2}{r^2}$$

$$g = \frac{Gm_1}{r^2}$$

$$F_c = \frac{mv^2}{r}$$

$$F_c = \frac{4\pi^2 mr}{T^2}$$

Momentum and Energy

$$\vec{p} = m\vec{v}$$

$$W = Fd$$

$$W = \Delta E = Fd\cos\theta$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$

$$E_k = \frac{1}{2}mv^2$$

$$E_p = mgh$$

$$E_p = \frac{1}{2}kx^2$$

Waves and Light

$$T = 2\pi\sqrt{\frac{m}{k}}$$

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$T = \frac{1}{f}$$

$$v = f\lambda$$

$$\frac{\lambda_1}{2} = l;\ \frac{\lambda_1}{4} = l$$

$$\frac{\sin\theta_1}{\sin\theta_2} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

$$\lambda = \frac{xd}{nl}$$

$$\lambda = \frac{d\sin\theta}{n}$$

$$m = \frac{h_i}{h_0} = \frac{-d_i}{d_0}$$

$$\frac{1}{f} = \frac{1}{d_0} + \frac{1}{d_i}$$

EQUATIONS

Electricity and Magnetism

$$F_e = \frac{kq_1q_2}{r^2}$$

$$\left|\vec{E}\right| = \frac{kq_1}{r^2}$$

$$\vec{E} = \frac{\vec{F}_e}{q}$$

$$\left|\vec{E}\right| = \frac{V}{d}$$

$$V = \frac{\Delta E}{q}$$

$$R = R_1 + R_2 + R_3$$

$$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$$

$$I_{\text{eff}} = 0.707\, I_{\max}$$

$$V = IR$$

$$P = IV$$

$$I = \frac{q}{t}$$

$$F_m = IlB_\perp$$

$$F_m = qvB_\perp$$

$$V = lvB_\perp$$

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{I_s}{I_p}$$

$$V_{\text{eff}} = 0.707\, V_{\max}$$

Atomic Physics

$$hf = E_{k_{\max}} + W$$

$$W = hf_0$$

$$E_{k_{\max}} = qV_{\text{stop}}$$

$$E = hf = \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} = R_H\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$

$$E_n = \frac{1}{n^2}E_1$$

$$r_n = n^2 r_1$$

$$N = N_0\left(\frac{1}{2}\right)^n$$

Quantum Mechanics and Nuclear Physics

$$E = mc^2$$

$$p = \frac{h}{\lambda}$$

$$p = \frac{hf}{c};\ E = pc$$

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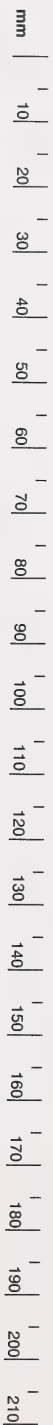

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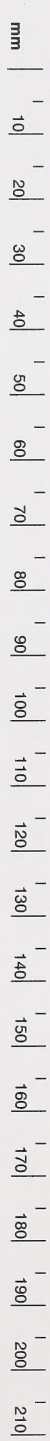

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